p.2, paragraph 1

The invention describes an apparatus and process which causes deuterium to participate in exothermic nuclear reactions in a condensed matter environment. The process uses solid state electrolysis device(s) that deposit D atoms onto, and/or remove D atoms from, a metal reactor plate containing deuterium diffusion-impeding ionic solid crystallites. The process recirculates deuterium that has not participated in a nuclear reaction during an earlier passage through the metal reactor plate.

p.2, paragraph 2

The process uses an assembly containing a metal reactor plate interfaced with either one or two solid-electrolyte layers. The assembly is mounted inside a containment enclosure pierced with hermetically sealed electrical feed-through fittings, and which is filled with deuterium gas D_2. The containment enclosure contains a metal reactor plate capable of absorbing deuterium, and which supports diffusion flow of deuterium in response to an internal deuterium density gradient. The reactor plate is fabricated so as to contain a dispersion of ionic solid crystallites that impede, but do not prevent deuterium diffusion flow within the plate. In a favored implementation of the process, the two exterior faces of the reactor plate are each coated with a solid state electrolyte. Each solid electrolyte layer is overcoated with a metal foil which is capable of dissolving deuterium. Metal foil, solid electrolyte, and contacting surface of the reactor plate form an electrolysis cell. There is an inflow electrolysis cell through which deuterium flows before entering the reactor plate, and an outflow electrolysis cell through which deuterium flows after leaving the reactor plate. The rims of the reactor plate, the two electrolyte layers, and the two metal foils are coated

with an electrical insulator, which constitutes an annular rim insulator. The annular rim insulator is penetrated at the metal plate's rim with an electrical conducting wire, which passes through one of the feed-through fittings so as to permit connection to an external source of voltage and current outside the containment enclosure. Separate electrical wires make contact with the two metal foils, and pass through the wall of the containment enclosure through separate metal feed-through fittings. All wire passages through the walls of the containment enclosure are vacuum-tight sealed. A hermetic gas input tube penetrates the containment enclosure wall. The input tube is used to introduce deuterium gas into the cell during a preparation period during which a desired initial quantity of deuterium dissolves into the various metal components and a desired initial quantity of deuterium gas fills the containment enclosure. The gas input tube can be sealed off before the process operation.

p. 3, paragraph 1

During the process operation, deuterium gas is absorbed into the positive electrode of the front electrolysis cell. The absorbed deuterium in ion form passes through the front electrolysis cell and enters the front layer of the reactor plate, flows through the reactor plate where it is subject to scatterings at many ionic solid metal interfaces, mostly passes out the back surface of the reactor plate into the back electrolysis cell with its covering metal foil, and re-enters the gas volume of the containment enclosure as deuterium gas. This deuterium circulation is driven by serial voltage potentials applied across the inflow and outflow electrolysis cells. The scattering process converts some of the diffusing deuterium into a nuclearly active configuration. The nuclearly active configuration deuterium

participates in exothermic nuclear reactions. Released nuclear energy converts into heat within the reactor plate. Subsequent heat transfer delivers the generated heat to a user application.

p. 4, paragrah 2

Three alternate implementations of the process are identical to those described above, except that they replace the use of a dispersion of diffusion-impeding ionic solid crystallites by the use of one or more diffusion-impeding non-metallic deuterium-scattering layers.

p. 4, Delete OBJECTS OF THE INVENTION as filed, and insert:

OBJECTS OF THE INVENTION

Iwamura et al. (1996) described an apparatus for testing permeation plate reactors for excess heat and nuclear emissions. The permeation property of the plate reactors was enabled by deuterium ion-in-metal diffusion. The apparatus used a heavy water-based (D_2O) electrolysis cell to deposit deuterium on the top surface of a horizontal permeation plate reactor. They removed outflow deuterium gas from the bottom surface of the reactor plate by a vacuum pump. They presented evidence for Watt-level excess heat in one run. Iwamura et al. (1998) reported studies which used essentially the same apparatus to test permeation plate reactors containing layered CaO crystallites, and reported 5 runs which produce Watt-level excess heat. The post-run reactor plates were reported to have new surface atoms that they believed might be transmutation products. They subsequently focused their studies on the surface transmutation process. Iwamura et al. (2002) describe apparatus that applied pressurized D_2 gas to

the inflow surface of a permeation plate reactor and used a vacuum pump to remove deuterium that had exited from the bottom of the reactor plate. They reported that when the apparatus used a deuterium permeation flow through a permeation plate reactor containing layered CaO inclusions, and when the inflow surface was also coated with a sub-monolayer of Cs, the Cs was quantitatively transmuted to Pr.

An object of the invention is to provide a D_2-fusion reactor that improves on the reactor apparatus described in Iwamura et al. (1998) by reducing the parasitic electric power that drives the permeation flow, thereby increasing excess heat power. Iwamura et al. (1998) used a liquid heavy-water-based electrolysis cell to deposit deuterium on the inflow surface of a permeation plate reactor. The Applicant's invention uses an input gas reservoir in combination with a solid electrolyte cell to convert D_2 gas into surface deuterium on the inflow surface of the same permeation plate reactor. The invention apparatus adds a second solid electrolyte cell to replace a vacuum pump used by Iwamura et al. (1998) to remove outflow deuterium that had exited the outflow surface of their reactor plate. In the invention outflow D_2 gas from the reactor plate assembly enters the input gas reservoir, completing a closed loop deuterium flow system.

Another object of the invention is elimination of a risk of explosion that is present in the Iwamura et al. (1998) process. In the Iwamura et al. (1998) process heavy water is dissociated to produce O_2 gas and hydrogen. Part of the hydrogen is in the form of D_2 gas. The apparatus includes a recombination catalyst to safely recombine any hydrogen gas mixed with the O_2 gas so as to prevent accumulation of an explosive mix. The invention process avoids use of a liquid electrolyte and avoids accumulation of a reactive neutral product like D_2 gas on the cell's anode. In the invention

process, the anode product is deuterium ions, which drift through the electrolyte as part of the closed-cycle deuterium flow system. No recombination catalyst is needed.

Another object of the invention is a reduced probability of contaminant atoms being deposited on the input surface of the permeation reactor plate. A solid electrolyte is less likely to contain contaminants than a liquid electrolyte bath, and the invention's lower polarizing voltage makes a contained contaminant less likely to be deposited on the cathode surface than occurs with the higher voltage used by Iwamura et al. (1998).

Another object of the invention is to increase the combination of a high deuterium chemical potential maintained on the front surface of the reactor plate together with a high permeation rate beyond that achieved in the Iwamura et al. (1998) process. This increase is made possible by the invention's use of an outflow electrolysis cell in addition to an inflow electrolysis cell.

Another object is to increase the heat output over that achieved in Iwamura et al. (1998) by providing the process operator with means for adjusting both the input deuterium chemical potential and the permeation flow rate by using independent adjustments on the potentials applied to the separate inflow and outflow solid electrolyte cells.

The Iwamura et al. (2002) achieved effective contaminant control over the input surface of its permeation plate reactor. An object of the invention is to maintain comparable contamination control while increasing the D_2 fusion heat generation rate by increasing the combined deuterium chemical potential maintained on the front surface of the permeation reactor plate and the permeation flow rate.

Another object of the invention is to provide apparatus and process that consistently demonstrate generation and release of radiationless D_2 fusion heat.

Another object of the invention is to provide apparatus and process that has improved utility as a test bed to enable reliable comparison of the heat generation capabilities of test permeation plate reactors that differ in design detail, such as in their internal distribution of ionic solid-metal interfaces, and the compositions, shapes and areas of the interfaces.

p.5, BRIEF DESCRIPTION OF THE DRAWINGS

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1, 2, and 5 are schematic cross sectional drawings illustrating two different assemblies that implement the invention;

Figure 1 is an edge view of an assembly that supports left-to-right deuterium permeation through a multi-crystallite scattering-layers reactor plate;

Figure 2 is a front end view of the assembly shown in Figure 1;

Figure 3 is an approximate one-million-times-magnified scaled cross sectional view of a portion of Figure 1 showing detail not shown in Figure 1;

Figure 4 is a picture of the ionic solid crystallite structure believed present in the CaO layers shown in Figure 3 and designated as item 11; and

Figure 5 is an alternative assembly that supports upward deuterium flow through a reactor plate.

p.6, paragraph 2

The invention apparatus supporting the nuclear process uses solid electrolyte electrolysis cells in contact with an Iwamura-type reactor plate to

maintain and control a continuous closed loop circulation of deuterium through the reactor plate at a higher flow rate and higher D/Pd ratio than exists during the Iwamura et al. 2002 experiments.

p. 10, paragraph 1

During process operation, absorption of deuterium on the left surface of reactor plate 2 and concurrent desorption of deuterium from the right side of reactor plate 2 drives a left-to-right permeation flow of deuterium through reactor plate 2. This permeation flow resembles that used in the studies by Iwamura et al. (2002 and 2003) and Higashiyama et al. (2003), which studies have demonstrated deuterium participation in exothermic nuclear reactions.

p. 10, insertion directly after p. 10, paragraph 1

The use of a left electrolyte cell in combination with a right electrolytic cell enables a cell operator to alter both permeation rate and average D/Pd ratio in reactor plate 2, so as to optimized fusion rates. When left metal foil is made more positive than reactor plate 2, permeation rate/cm^2 is increased and average D/Pd ratio is increased. When reactor plate 2 is made more positive than right metal foil 4, permeation rate/cm^2 is increased while average D/Pd ratio is decreased. When reactor plate 2 is made more negative that right metal foil 4, permeation rate/cm^2 is decreased, and average D/Pd ratio is increased. Calculations show that potential differences of 0.1 volt are sufficient to drive useful permeation using negligible power.

p. 10, paragraph 2

Although theory and conjecture are not part of the description of the apparatus and process, the description is aided by summarizing the science that seems to explain the Iwamura et al. and Higashiyama et al. results. In T.

A. Chubb "The dd Cold Fusion-Transmutation Connection" a quantum mechanics wave equation-wave function model explains how the prescribed permeation flow leads to exothermic nuclear reactions. Quantum mechanics coordinate exchange replaces quantum mechanics tunneling in the reaction model.

p. 11, paragraph 1

The total deuterium permeation flow is modeled as being partitioned between a relatively large diffusion flow of non-nuclearly-active interstitial deuterium within the metal and a relatively small independent conduction flow carried by nuclearly-active wavelike deuterium. The normal form of deuterium in a metal is the non-nuclearly-active interstitial configuration. The normal diffusion flow is driven by a concentration gradient of deuterium in self-trapping potential wells. The normally occupied potential wells in Pd metal are known to be centered on the octahedral sites of the face-centered cubic (fcc) metal lattice. The conduction flow is modeled as being carried by wavelike deuterons occupying shallower, non-self-trapping potential wells, as described in T. A. Chubb "LENR: Superfluids, Self-Trapping and Non-Self-Trapping Sites". In the Iwamura work the non-self-trapping wells are believed to be located in the interface between ionic solid and adjacent metal, as explained in T. A. Chubb "Inhibited diffusion driven surface transmutations". At each of the CaO diffusion-impeding layers there is a scattering of both types of deuterium. The scatterings are modeled as reversible scatterings of individual deuterons between self-trapping and non-self-trapping sites. Reversibility requires that a fraction of the normally diffusing deuterons scatter into wavelike deuterons when they cross a diffusion-impeding layer. The resulting wavelike deuterons in the non-self-

trapping sites are the nuclearly reactive component which, in Iwamura et al. (2002) spreads out in all directions and participates in exothermic nuclear reactions on the metal surface, releasing heat. The summed nuclear reactions demonstrated by Iwamura et al. and Higashiyama et al. are $^{133}Cs + 8D \rightarrow {}^{141}Pr + 50.5$ MeV and $^{88}Sr + 8D \rightarrow {}^{96}Mo + \sim 53.5$ MeV.

p. 12, insertion directly after p.11, paragraph 1

Prior to the Iwamura et al. (2002) transmutation studies, Iwamura et al. (1998) used a deuterium oxide (D_2O) liquid electrolysis cell as input to a permeation reactor, and produced more nuclear heat than in their later work. Applying understanding gained from the Iwamura et al. (2002) teaching, the Applicant developed an improved version of the Iwamura et al. (1998) apparatus. The invention apparatus and process avoids D_2O electrolyte, removes a source of reactor plate surface contamination, supports closed loop operation, and substantially reduces electric input power.

p. 14, paragraph 1

Three additional implementations of the process are identical to the three implementations described above, except that they use a different internal diffusion-impeding structure within reactor plate 2. Instead of using thin non-metallic diffusion-impeding layers, the processes use an internal dispersion of ionic solid crystallites providing contacting ionic solid-metal interfaces within reactor plate 2 as means for scattering nuclearly non-reactive diffusing deuterium into the nuclearly reactive configuration. Figures 3 and 4 explain the rationale for using a dispersion of salt-like inclusions in the reactor plate. The high crystallinity of the CaO used by Iwamura et al. suggests that the deposition process leads to distinct

crystallites 11 embedded in Pd metal 16, instead of a continuous layer, as shown in Figure 3 and as described in T. A. Chubb "Inhibited diffusion driven surface transmutations". The left surface 17 of the Pd plate shown in Figure 3 is the inflow surface of the reactor plate as used by Iwamura et al. (2002). Since the interface between CaO crystallite and Pd metal is the deuteron nuclear fusion site in the Iwamura et al. (1996, 1998 and 2002) reactors, use of a more general distribution of ionic solid crystallites resembling the crystalline fragments 11 of the diffusion-impeding CaO layers is within the scope of the invention.

p. 15, paragraph 1

Many modifications and variations of the assembly hardware supporting process operation are possible in light of the above teachings. Among these is that of inserting additional permeation plate reactors into the closed loop deuterium flow path, and that of inserting heat exchanger assemblies adjacent to the permeation plate reactors to deliver fusion heat to a user. Also, among these is the application of an AC potential across individual solid electrolyte layers to provide initial heat to raised the temperature of the attached permeation plate to a desired operating temperature. Also, among these is that of replacing the planar sequence of component layers with a cylindrical sequence of the same functional elements. Also, it is well known in the art of fuel cell technology and in the physics of metal-hydrogen systems that one can coat a metal's surface with fine Pd powder or Pd-Ag alloy powder, thereby increasing the effective surface area for absorption of hydrogen into the metal's bulk. Also, it is well known in prior art that use of Pd coatings on a metal's de-oxidized surface can permit absorption of hydrogen into a metal's bulk for metals which form

oxides that otherwise block absorption of hydrogen. Use of such surface treatments on the metal foil(s) and/or on the reactor plate, and use of metals other than Pd or Pd alloys for the foil(s) and/or reactor plate within the assembly should be considered as within the scope of the invention. Furthermore, use of internal non-metallic layers made of materials other than CaO within a reactor plate have been taught by Iwamura et al. The number, placement, uniformity, and thickness of the internal non-metallic layers can be widely varied provided that deuterium permeation is not prevented, and provided that the impeding of the deuterium permeation flow is sufficient to scatter amounts of deuterium into the nuclearly reactive state that are comparable to, or greater than the amounts achieved by Iwamura et al. (2002). For example, inclusion of both a left and right grouping of diffusion-impeding layers could be used with back and forth deuterium permeation flow through reactor plate 2 of Figure 1. Addition of voltage control circuitry using signals from pressure transducer 13 together with temperature readings as a basis for setting the electrolysis cell voltages should be considered as within the scope of the invention. The invention can also be used in conjunction with various laser and acoustic stimulation devices, such as are being used as enhancers in cold fusion test devices. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.